

THE INFLUENCE OF ALCOHOL AND ALCOHOLIC DRINKS
UPON THE CHEMICAL PROCESSES OF DIGESTION.

By R. H. CHITTENDEN, PH.D.,
PROFESSOR OF PHYSIOLOGICAL CHEMISTRY IN YALE UNIVERSITY;

AND
LAFAYETTE B. MENDEL, PH.D.,
INSTRUCTOR IN PHYSIOLOGICAL CHEMISTRY.

(Continued from p. 193.)

LAGER BEER (WITH 1.5 PER CENT. OF ALCOHOL AND 7 PER CENT.
OF SOLID MATTER).

Experiment 107.

Period of digestion 8 hours.

Beer.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5388 gram.	46.2 per cent.	100.0
1 " "	0.5596 "	44.1 "	95.4
3 " "	0.5769 "	42.4 "	91.7
5 " "	0.5817 "	41.9 "	90.7
10 " "	0.6147 "	38.6 "	83.5

Experiment 108.

Period of digestion $7\frac{1}{2}$ hours.

Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3203 gram.	68.0 per cent.	100.0
10 " beer	0.3602 "	64.0 "	94.1
10 " " distillate	0.3487 "	65.2 "	95.8
10 " " residue	0.3480 "	65.2 "	95.8
1 " absol. alcohol	0.3439 "	65.7 "	96.6

PORTER (WITH 3.7 PER CENT. OF ALCOHOL AND 4.4 PER CENT. OF
SOLID MATTER).

Experiment 109.

Period of digestion $7\frac{1}{2}$ hours.

Porter.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.5102 gram.	49.0 per cent.	100.0
1 " "	0.5095 "	49.1 "	100.2
3 " "	0.5104 "	49.0 "	100.0
5 " "	0.5267 "	47.4 "	96.7
10 " "	0.5834 "	41.7 "	85.1
Absolute alcohol.			
1 per cent.	0.5318 "	46.9 "	95.7

*Experiment 110.*Period of digestion $5\frac{1}{2}$ hours.

	Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0	per cent.	0.3919 gram.	60.9 per cent.	100.0
1	" porter	0.4059 "	59.5 "	97.7
10	" "	0.4719 "	52.9 "	86.8
10	" " distillate	0.4071 "	59.3 "	97.3
10	" " residue	0.4163 "	58.4 "	95.8
1	" absol. alcohol	0.4015 "	59.9 "	98.3

BASS'S ALE (WITH 4 PER CENT. OF ALCOHOL AND 4.4 PER CENT. OF SOLID MATTER).

*Experiment 111.*Period of digestion $7\frac{1}{2}$ hours.

	Ale.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0	per cent.	0.4671 gram.	53.3 per cent.	100.0
1	"	0.4624 "	53.8 "	100.9
3	"	0.4949 "	50.6 "	94.9
5	"	0.5160 "	48.4 "	90.8
10	"	0.5311 "	46.9 "	87.9

*Experiment 112.*Period of digestion $7\frac{1}{2}$ hours.

	Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0	per cent.	0.3203 gram.	68.0 per cent.	100.0
10	" ale	0.3772 "	62.3 "	91.6
10	" " distillate	0.3386 "	66.2 "	97.3
10	" " residue	0.3684 "	63.2 "	92.9
1	" absol. alcohol	0.3439 "	65.7 "	96.6

The following experiment shows the comparative action of these malt liquors when tested under exactly the same conditions:

Experiment 113.

Period of digestion 5 hours.

	Fluid added.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0	per cent.	0.3919 gram.	60.9 per cent.	100.0
10	" beer	0.4466 "	55.4 "	90.9
10	" ale	0.4686 "	53.2 "	87.3
10	" porter	0.4719 "	52.9 "	86.8
1	" absol. alcohol	0.4015 "	59.9 "	98.3

From these results it is manifest that the malt liquors, as represented by the above samples, have far less retarding action on trypsin-proteolysis than do wines. This fact, however, is not connected with the smaller

content of alcohol, but rather with the amount and character of the extract or solid matter of the fluid. Thus, lager beer, with only 1.5 per cent. of alcohol, when present in small amount, has a greater retarding action than either porter or ale, although these fluids contain 3-4 per cent. of alcohol. The beer, however, contains nearly twice as much solid matter as the other fluids, and its greater inhibitory power is presumably due to this cause. Small amounts of porter and ale have no noticeable retarding action whatever, but the presence of 5 or 10 per cent. of either of these malt liquors leads to a decided diminution of digestive power.

None of these malt liquors was very strongly acid; thus, the acidity of the ale was only slightly above that of the sample of rum, while the lager beer was considerably less acid. The porter alone was strongly acid, its acidity being nearly half that of the sherry wine. Plainly, the acidity of these malt fluids is not a very important factor in their retarding action on trypsin-proteolysis.

Doubtless, many non-alcoholic beverages have an equally pronounced inhibitory action on the digestive processes, owing to the presence of inorganic salts and other extractives. Tea and coffee, owing to the tannin they contain, are known to exert such an influence, and we may cite the following experiment with ginger ale as an illustration of inhibitory action caused presumably by the extractive matters contained therein:

Experiment 114.

Period of digestion 7 hours.

Ginger ale.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.3260 gram.	67.4 per cent.	100.0
1 "	0.3553 "	64.5 "	95.7
3 "	0.3574 "	64.3 "	95.4
5 "	0.3562 "	64.4 "	95.5
10 "	0.3866 "	61.4 "	91.0
Absolute alcohol.			
1 per cent.	0.3361 "	66.4 "	98.5

In contrast to this experiment, we report the following results obtained with bottled "soda water"; *i. e.*, water simply charged with carbonic-acid gas, which may be offered as evidence that it is possible to have pancreatic digestion without retardation.

Experiment 115.

Period of digestion 6½ hours.

Soda water.	Undigested fibrin.	Proteid digested.	Relative proteolytic action.
0 per cent.	0.4692 gram.	53.1 per cent.	100.0
1 "	0.4695 "	53.1 "	100.0
3 "	0.4675 "	53.3 "	100.3
5 "	0.4690 "	53.1 "	100.0

COMPARATIVE ACTION OF SOME ALCOHOLIC LIQUORS ON TRYPSIN-PROTEOLYSIS.

The comparative action of some of these alcoholic liquors may be seen from the following results which are taken from preceding experiments, where all of the conditions were strictly comparable :

Per cent. of alcoholic fluid in digestive mixture.	Relative proteolytic action.		
	Rum.	Brandy.	Proof-spirits.
0 per cent.	100.0	100.0	100.0
10 "	88.0	89.8	90.5
	Whiskey.	Sherry.	
0 per cent.	100.0	100.0	
10 "	89.1	82.4	
	Claret.	Hochheimer.	
0 per cent.	100.0	100.0	
10 "	65.0	74.0	
	Beer.	Ale.	
0 per cent.	100.0	100.0	
10 "	94.1	91.6	

In concluding this chapter of our subject, we may repeat that distilled alcoholic liquors, such as whiskey, brandy, etc., have a far greater retarding action upon trypsin-proteolysis than upon pepsin-proteolysis. Further, this retardation is not due wholly to the contained alcohol, but is attributable in part to the solid matter present. This latter, however, in a distilled liquor should obviously be very small, and it is quite apparent that if due care is used in the distillation and rectification of such a liquor and no additions are made, the only solid matter should be such as is extracted from the cask in which the liquor is stored. The liquors in question, however, did contain some extractive matter other than tannin, and to this material, as well as to the tannin and the alcohol, the retardation of trypsin-proteolysis is unquestionably due. Wines, with their high acidity and low alcoholic strength, exert a retarding action on tryptic digestion more nearly proportional to the acidity than to the amount of alcohol, or even to their content of solid matter. All three of these elements, however, undoubtedly combine to produce the results recorded. The malt liquors, on the other hand, owe their retarding influence mainly to the large percentage of extractives of various sorts which they contain, the alcohol playing a minor part in the inhibition caused by the fluids of this class.

SALIVARY DIGESTION.

In considering the influence of alcoholic beverages on salivary digestion, it is to be remembered that the latter process has for its main object the digestion of the farinaceous foods. This property is shared

in common with the pancreatic juice, the utilization of all farinaceous foods by the body being dependent almost wholly upon the so-called amylolytic power of these two secretions.

Salivary digestion is a comparatively rapid process, the transformation of the insoluble starch into soluble dextrins and sugar taking place in a relatively short period, as contrasted with the proteolytic action of either the gastric or pancreatic juice. Amylaceous or farinaceous foods are exposed to the action of the saliva in the mouth for only a short interval, but the evidence at present available points to the probable continuation of salivary digestion in the stomach for from ten to thirty minutes before the amylolytic ferment is killed by the increasing acidity of the gastric juice. In view of this relatively short period of digestion, retardation of amylolytic action may become a serious matter, since even slight retardation may mean the loss of more or less nutriment to the body. The amylolytic ferment of the pancreatic juice, however, may be able to convert the unchanged starch in the small intestine, providing the influence of the retarding agent does not extend so far. But in any event, retardation or stoppage of salivary digestion must be a serious evil, and it is to be remembered that the amylolytic ferment of the pancreatic juice is closely akin to, if not identical with, the ferment of the saliva, and hence is susceptible to the same influences that affect the salivary ferment.

METHODS EMPLOYED.

In testing the influence of alcoholic liquors on the salivary digestion of starchy foods the following method was most generally employed: Ten c.c. of a freshly prepared starch-paste (1 per cent.) were introduced into a suitable flask, a given volume of the alcoholic fluid together with sufficient water to make the resultant mixture up to 90 c.c. added; and, lastly, 10 c.c. of neutralized and filtered saliva, which had been previously diluted to some definite volume. The completed mixture was thus composed of 100 c.c. The time at which the saliva was added was carefully noted, and the mixture placed in a suitable water-bath kept at 38°–40° C. In order to measure the rate of digestion a drop of fluid was withdrawn at intervals, placed on a white porcelain surface, and tested with a drop of a dilute iodine-solution. The color obtained with iodine under these conditions is dependent upon the extent of amylolytic action. Thus, the presence of soluble starch, the first product formed, is indicated by a blue color. As digestion proceeds the blue color gives place to a reddish color with iodine, owing to the presence of erythrodextrin, while the final products of amylolytic action, maltose and achroödextrins, give no color whatever with iodine. The time when this so-called "achromic" point is reached is carefully noted, and the

number of minutes required for the appearance of the "achromic" point serves as a measure of the rate of amylolytic action.

A method less frequently used in our experiments, but better adapted to measuring accurately small shades of difference, was as follows: One gram of arrowroot-starch was made into a paste with 40 c.c. of water, 50 c.c. of water alone (in the control) or with the required volume of alcoholic fluid to give the desired percentage were then added; and, lastly, 10 c.c. of a diluted neutral saliva. The mixture, or series of mixtures, was then placed in a bath at 38°–40° C. for thirty minutes, after which the solution was heated to boiling to prevent further action of the enzyme. The resultant solution was then made up to 150 c.c., and the extent of amylolytic action ascertained by determining in one-sixth of the solution the amount of maltose formed by the use of Allihn's¹ gravimetric method. From the amount of reduced copper thus obtained, the amount of maltose was calculated on the basis of Salomon's² statement that 100 parts of anhydrous maltose will form 114 parts of reduced copper when boiled with Fehling's solution after the Allihn method.

It is, of course, understood that in both methods all of the mixtures belonging to a given series were treated with the same specimen of saliva.

ABSOLUTE ALCOHOL (99.5 TO 100 PER CENT.).

Experiment 116. (Saliva 1:15.)³

Alcohol.	Appearance of the achromic point.
0 per cent.	7 minutes.
0.5 "	7 "
1.0 "	7 "
2.0 "	7 "
5.0 "	7 "
10.0 "	7 "

Experiment 117. (Saliva 1:20.)

Alcohol.	Appearance of the achromic point.
0 per cent.	7 minutes.
1 "	7 "
10. "	7 "

¹ Zeltseh. f. Analyt. Chemie, Band xxii. p. 448.

² Journal für Praktische Chemie, Band xxviii. p. 109.

³ Being the dilution of the saliva added to the digesting mixture; i. e., 1 part of fresh saliva in 15 parts of water. It is to be remembered, however, that in the digestive mixtures (100 c.c.) the dilution of the saliva is increased tenfold.

Experiment 118. (Saliva 1:30.)

Alcohol.	Appearance of the achromic point.
0 per cent.	27 minutes.
0.5 "	27 "
1.0 "	27 "
2.0 "	27 "
5.0 "	27 "
10.0 "	25 "

From these results it is plainly manifest that absolute alcohol has very little influence upon the amylolytic or starch-digesting power of neutral saliva. Only when the saliva, added to the digestive mixture, is diluted in the proportion of 1 to 30 does the presence of even 10 per cent. of alcohol have any measurable influence, and then only to retard the appearance of the achromic point two minutes. As this percentage of absolute alcohol is equal to at least 20 per cent. of proof-spirit, it follows that pure alcohol free from admixture is practically without influence upon the digestion of farinaceous foods by the saliva.

A more accurate testing of this question was attempted by the use of the second method above described, with the following results:

Experiment 119. (Saliva 1:4.)

Alcohol.	Reduced copper in $\frac{1}{4}$.	Maltose formed.	Relative amylolytic action.
0 per cent.	0.0885 gram.	31.05 per cent. ¹	100.0
0.5 "	0.0918 "	32.21 "	103.7
1.0 "	0.0908 "	31.86 "	102.6
3.0 "	0.0911 "	31.96 "	102.9
5.0 "	0.0897 "	31.47 "	101.3
10.0 "	0.0862 "	30.25 "	97.4

Experiment 120. (Saliva 1:5.)

Alcohol.	Reduced copper in $\frac{1}{5}$.	Maltose formed.	Relative amylolytic action.
0 per cent.	0.1436 gram.	75.5 per cent.	100.0
5 "	0.1439 "	75.7 "	100.2
0 "	0.1367 "	71.9 "	95.2
"	0.1309 "	68.0 "	90.0

Experiment 121. (Saliva 1:4.)

Alcohol.	Reduced copper in $\frac{1}{4}$.	Maltose formed.	Relative amylolytic action.
0 per cent.	0.122 gram.	64.2 per cent.	100.0
5 "	0.120 "	63.1 "	98.2
10 "	0.119 "	62.5 "	97.3
15 "	0.114 "	60.0 "	93.4

¹ Calculated on the 1 gram of starch employed.

Experiment 122. (Saliva 1:2.)

Alcohol.	Reduced copper in $\frac{1}{16}$.	Maltose formed.	Relative amylolytic action.
0 per cent.	0.132 gram.	69.4 per cent.	100 0
5 "	0.131 "	68.9 "	99.2
10 "	0.126 "	66.3 "	95.5
15 "	0.125 "	65 7 "	94.6

At first glance, these results would seem to be somewhat opposed to those obtained in the first series of experiments, but such is not the case. The first method simply tells us the time when all the starch has been transformed into achroödextrin and maltose. The second method, however, tells us more than this, viz., the actual amount of maltose that has been formed, and as a certain amount of achroödextrin can be transformed into maltose by the continued action of the salivary ferment it follows that this latter method gives us a clearer knowledge of the influence of alcohol upon the secondary action of the amylolytic enzyme. Thus, we find that small amounts of absolute alcohol may actually cause an increased formation of maltose. On the other hand, the presence of 10 or 15 per cent. of absolute alcohol leads to a distinct retardation in the formation of sugar, although the inhibition is not very pronounced considering the amount of alcohol present. This retardation of the secondary action of the ferment is perhaps suggested by the slight delay in the appearance of the achromic point in Experiment 118, in the presence of 10 per cent. of absolute alcohol.

WHISKEY (WITH 50 PER CENT. OF ALCOHOL).

Experiment 123. (Saliva 1:30.)

Whiskey.	Appearance of the achromic point.
0 per cent.	28 minutes.
0.5 "	22 hours.
1.0 "	no action beyond erythrodestrin. ¹
2.0 "	no action whatever. ²
5.0 "	" "

Experiment 124. (Saliva 1:25.)

Whiskey.	Appearance of the achromic point.
0 per cent.	6 minutes.
0.5 "	8 "
1.0 "	17 hours.
2.0 "	no action beyond soluble starch.
5.0 "	no action at all.
Absolute alcohol.	
2.5 per cent.	6 minutes.

¹ The final observation was always made at the end of twenty-four hours.² Ibid.

Experiment 125. (Saliva 1:20.)

Whiskey.	Appearance of the achromic point.
0 per cent.	7 minutes.
0.5 "	8 "
1.0 "	9 "
2.0 "	no action beyond erythrodextrin.
5.0 "	no action whatever.
Absolute alcohol.	
2.5 per cent.	7 minutes.

Experiment 126. (Saliva 1:15.)

Whiskey.	Appearance of the achromic point.
0 per cent.	5 minutes.
0.5 "	5 "
1.0 "	7 "
2.0 "	24 hours.
5.0 "	no action whatever.
Absolute alcohol.	
2.5 per cent.	5 minutes.

Experiment 127. (Saliva 1:7.)

Whiskey.	Appearance of the achromic point.
0 per cent.	3 minutes.
2 "	5 "
5 "	no action beyond erythrodextrin.
10 "	no action whatever.
Absolute alcohol.	
5 per cent.	3 minutes.

Experiment 128. (Saliva 1:3.)

Whiskey.	Appearance of the achromic point.
0 per cent.	3 minutes.
5 "	4 "
10 "	24 hours.
Absolute alcohol.	
5 per cent.	3 minutes.

Experiment 129. (Saliva 1:4.)

Whiskey.	Reduced copper in $\frac{1}{\%}$.	Maltose formed.	Relative amylolytic action.
0 per cent.	0.109 gram.	57.3 per cent.	100.0
5 "	0.110 ¹ "	57.8 "	100.8
10 "	0.080 "	42.0 "	73.3
15 "	0.010 "	5.2 "	9.0

From these results it is apparent that whiskey may have a very great retarding action upon salivary digestion, the retardation being the more

¹ Allowance being made for the reduction obtained from a corresponding amount of the whiskey alone.

pronounced the greater the dilution of the saliva. When, however, the saliva is diluted only three or four times, so that the proportion of saliva in the digestive mixture is as 1:30 or 1:40, then the presence of even 5 per cent. of whiskey is wholly without action. It is furthermore apparent that the alcohol of the whiskey plays no part in this inhibitory action. What now is the cause of the retardation? In this connection it is to be remembered that all the whiskeys examined by us have shown an acid reaction; furthermore, the saliva used in our experiments was neutralized saliva. Taking into consideration the well-known sensitiveness of the salivary ferment toward acids, the question naturally presents itself whether this retardation of amylolytic action caused by the whiskey is not due to the acidity of the fluid. This question we attempted to answer by the following experiments:

Experiment 130. (Saliva 1:15.)

Fluid added.		Appearance of the achromic point.
0 per cent.		4 minutes.
2.0	" whiskey	24 hours.
2.0	" " neutralized	7 minutes.
1.0	" absolute alcohol	4 "

Experiment 131. (Saliva 1:25.)

Fluid added.		Appearance of the achromic point.
0 per cent.		9 minutes.
1	" whiskey	24 hours.
1	" " neutralized	22 minutes.
5	" " "	no action.
5	" " neutralized	partial action.
10	" " " "	" "
2.5	" absolute alcohol	11 minutes.

From these results it is apparent that the retarding action of the whiskey is in great part overcome by neutralization of the liquor, providing the saliva is not too greatly diluted. It is furthermore apparent that with unneutralized saliva—*i. e.*, with the normally alkaline secretion—the retarding action of at least small quantities of whiskey would be far less than is indicated by the above results. Indeed, it may be safely said that with a fair volume of unneutralized, and not too greatly diluted saliva, the presence of even 5 per cent. of whiskey would be practically without action on the salivary digestion of farinaceous foods, a conclusion which Roberts has likewise reached. Obviously, however, the degree of acidity of a given sample of whiskey, together with the natural alkalinity of the saliva, would be important factors in determining the precise character of the result.

In this connection the question may properly be asked why we employed neutralized saliva in our experiments, instead of the normally

alkaline fluid? To this we would answer that in no other way was it possible to obtain constant and comparable conditions, since the alkalinity of the secretion is ever variable, and, moreover, every variation in the dilution of the fluid would obviously cause a corresponding variation in the degree of alkalinity. Further, the best action of saliva is normally obtained when the fluid is neutral, and the natural tendency of the food-stuffs is toward neutralization of the secretion, both in the mouth and in the stomach. Again, since the fluids we were testing all have an acid reaction, it seemed more probable that we should obtain a trustworthy indication of the action of these fluids upon the amylolytic ferment by using a neutral solution of the enzyme.

In conclusion, then, we may repeat that the retardation of amylolytic action caused by large amounts of whiskey is not closely connected with the amount of alcohol the liquor contains, but is more intimately associated with the presence of volatile, acid-reacting bodies; possibly also ethereal bodies, volatile oils, and perhaps also tannin. Hence, the greater the purity of the whiskey, the less will be its retarding action upon the digestion of the farinaceous food-stuffs.

That the solid, non-volatile portions of the whiskey that we experimented with have no retarding action upon the amylolytic power of the saliva is shown by the following experiment made with the residue left on evaporation of the whiskey; an experiment which also shows that the acid-reacting bodies present in the whiskey are volatilized by heat:

Experiment 132. (Saliva 1:4.)

Whiskey residue. ¹	Reduced copper in $\frac{1}{2}$.	Maltose formed.	Relative amylolytic action.
0 per cent.	0.091 gram. ²	47.8 per cent.	100.0
5 "	0.115 "	60.4 "	126.3
10 "	0.113 "	59.4 "	124.2
15 "	0.103 "	54.1 "	113.1

So far as these results go, they indicate that the solid matter present in this sample of whiskey when free from alcohol and the volatile acid-reacting bodies has a marked stimulating action upon salivary digestion. Whether this result may be expected from all whiskeys is, of course, uncertain.

¹ The residue dissolved in water. The percentages refer to the residue obtained from those percentages of whiskey.

² Deduction being made for the reducing power of the residue itself.